# Mission Assurance Requirements
# For Living With A Star (LWS) Projects

## DRAFT

September 17, 2001

**Prepared by:**

**Laurie E. Kleppin**
**Systems Assurance Manager**

**Approved by:**

**LWS Program Manager**

**Approved by:**

**Wentworth Denoon**
**Director, Office of Systems Safety**
**And Mission Assurance**

**The purpose of this document is to concisely present the safety and assurance requirements that may be necessary for projects in the LWS Program. These requirements will be tailored for specific projects and incorporated into LWS developer contract documents.**

**TABLE OF CONTENTS**

**CHAPTER 1. OVERALL REQUIREMENTS ........ 1**
1.0 GENERAL ........ 1
1.1 DESCRIPTION OF OVERALL REQUIREMENTS ........ 1
1.2 USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE ........ 2
1.3 SURVEILLANCE OF THE DEVELOPER ........ 2
1.4 SAFETY AND MISSION ASSURANCE VERIFICATION ........ 2
1.5 APPLICABLE DOCUMENTS ........ 2
1.6 ACRONYMS AND GLOSSARY ........ 2

**CHAPTER 2. QUALITY MANAGEMENT SYSTEM ........ 3**
2.0 QUALITY MANAGEMENT SYSTEM ........ 3
2.1 SUPPLEMENTAL QUALITY MANAGEMENT SYSTEM REQUIREMENTS ........ 3
2.1.1 Nonconformance Reporting and Corrective Action ........ 3
2.1.2 Control of Monitoring and Measuring Devices ........ 4
2.1.3 Configuration Management ........ 4
2.2 GROUND SUPPORT EQUIPMENT ........ 4
2.3 REQUIREMENTS FLOW-DOWN ........ 4

**CHAPTER 3. SYSTEM SAFETY REQUIREMENTS ........ 5**
3.0 GENERAL REQUIREMENTS ........ 5
3.1 SYSTEM SAFETY IMPLEMENTATION PLAN ........ 5
3.2 SAFETY PACKAGE ........ 5
3.3 SUPPORT FOR SAFETY WORKING GROUP MEETINGS ........ 6
3.4 ORBITAL DEBRIS ASSESSMENT ........ 6
3.5 SOFTWARE SAFETY ASSURANCE ........ 6

**CHAPTER 4. RISK MANAGEMENT REQUIREMENTS ........ 7**
4.0 GENERAL RISK MANAGEMENT REQUIREMENTS ........ 7
4.1 RISK MANAGEMENT PLAN ........ 7

4.3.5 Reliability Assessments and Predictions ....9
4.3.6 Software Reliability ....10
4.4 RELIABILITY ANALYSIS OF TEST DATA ....10
4.4.1 Trend Analyses ....10
4.4.2 Analysis of Test Results ....10
4.5 LIMITED-LIFE ITEMS....10
4.6 CONTROL OF SUBDEVELOPERS AND SUPPLIERS ....11

**CHAPTER 5. SOFTWARE ASSURANCE REQUIREMENTS ....12**
5.0 GENERAL REQUIREMENTS....12
5.0.1 Management Review....12
5.0.2 Peer Review....12
5.1 SOFTWARE QUALITY ASSURANCE ....12
5.1.1 Software Quality Assurance Plan....12
5.1.2 Process Monitoring ....13
5.2 SOFTWARE QUALITY ENGINEERING....13
5.2.1 Software Configuration Management ....13
5.2.2 Software Reliability, Maintainability, Transportability.... **Error! Bookmark not defined.**
5.2.3 Status Reporting....13
5.3 SOFTWARE VERIFICATION AND VALIDATION ....13
5.3.1 Verification and Validation Activities....14
5.3.2 Independent Verification and Validation....14
5.4 GFE, EXISTING AND PURCHASED SOFTWARE AND FIRMWARE....14

**CHAPTER 6. TECHNICAL REVIEW REQUIREMENTS....15**
6.0 GENERAL REQUIREMENTS....15
6.1 PHASE B REVIEWS ....15
6.2 PHASE C/D REVIEWS....16
6.3 PEER REVIEWS....16
6.4 REVIEW ACTION ITEM TRACKING....16

**CHAPTER 7. DESIGN VERIFICATION REQUIREMENTS ....17**

7.2.1 Environmental Verification Plan.................................... **Error! Bookmark not defined.**

7.2.2 Environmental Verification Specification ....................... **Error! Bookmark not defined.**

7.2.3 Environmental Test Matrix (ETM) ................................ **Error! Bookmark not defined.**

7.3 END-TO-END TEST.......................................................... **ERROR! BOOKMARK NOT DEFINED.**

7.4 DEMONSTRATION OF FAILURE-FREE OPERATION ..... **ERROR! BOOKMARK NOT DEFINED.**

**CHAPTER 8. WORKMANSHIP STANDARDS ....................................................................................19**

8.0 GENERAL REQUIREMENTS ....................................................................................19

8.1 APPLICABLE DOCUMENTS* ....................................................................................19

8.2 DESIGN....................................................................................................................19

8.2.1 Printed Wiring Boards....................................................................................19

8.2.2 Assemblies....................................................................................................20

8.2.3 Ground Systems That Interface With Space Flight Hardware .......................................20

8.3 WORKMANSHIP REQUIREMENTS.........................................................................20

8.3.1 Training and Certification ..............................................................................20

8.3.2 Flight and Harsh Environment Ground Systems Workmanship ....................................20

8.3.3 Ground Systems (non-flight) Workmanship.................................................................20

8.3.4 Documentation...............................................................................................20

8.4 NEW OR ADVANCED PACKAGING TECHNOLOGIES.......................................................21

8.5 HARDWARE HANDLING.........................................................................................21

8.6 ELECTROSTATIC DISCHARGE CONTROL REQUIREMENTS...........................................21

**CHAPTER 9. PARTS REQUIREMENTS ..........................................................................................22**

**CHAPTER 10. PARTS REQUIREMENTS** ................................................... ERROR! BOOKMARK NOT DEFINED.

10.0 GENERAL...............................................................................................................22

10.1 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS.....................22

10.1.1 Parts Control Board.....................................................................................22

10.1.2 Parts Selection and Processing.....................................................................22

10.1.3 De-rating ......................................................................................................23

10.1.4 Radiation Hardness .....................................................................................23

10.1.5 Verification Testing .....................................................................................23

11.1.1 Materials Identification List....25
11.1.2 Compliant Materials....25
11.1.3 Vacuum Outgassing....26
11.1.4 Non-compliant Materials....26
11.1.5 Conventional Applications (Definition)....26
11.1.6 Non-conventional Applications (Definition)....26
11.1.7 Polymeric Materials....26
11.1.8 Shelf-Life-Controlled Materials....26
11.1.9 Inorganic Materials....26
11.1.10 Lubrication....27
11.2 PROCESS SELECTION REQUIREMENTS....27
11.3 PROCUREMENT REQUIREMENTS....27
11.3.1 Purchased Raw Materials....27
11.3.2 Raw Materials Used in Purchased Products....27

**CHAPTER 12. CONTAMINATION CONTROL REQUIREMENTS....34**
12.0 GENERAL REQUIREMENTS....34
12.1 CONTAMINATION CONTROL PLAN....34
12.1.1 Contamination Control Verification Process....34
12.2 MATERIAL OUTGASSING....34
12.3 THERMAL VACUUM BAKEOUT....34

**CHAPTER 13. GIDEP ALERTS AND PROBLEM ADVISORIES....35**
13.0 GENERAL REQUIREMENTS....35
13.1 GIDEP ALERT RESPONSE....35
13.2 DOCUMENTATION....35

**CHAPTER 14. APPLICABLE DOCUMENTS LIST....36**

**CHAPTER 15. ACRONYMS AND GLOSSARY....39**
15.0 ACRONYMS....39
15.1 DEFINITIONS....41

# Chapter 1. Overall Requirements

## 1.0 GENERAL

The purpose of this document is to concisely present the safety and mission assurance (SMA) requirements that may be necessary for projects in the Living With a Star (LWS) Program. These requirements will be tailored for specific projects and incorporated into LWS developer contract documents.

The LWS program is comprised of a variety of missions with varying levels of criticality and acceptable risks. The LWS Program encompasses a wide variation in complexity, size, and technologies required of the developer and critical suppliers; these all can affect program risk and costs. A primary mission with a high level of mission criticality and low level of acceptable risk should plan for a set of safety and mission assurance requirements that is more stringent than the requirements for missions of opportunity or test bed platform.

Reliability considerations for the LWS Program are bounded by programmatic demands for scientific excellence, low cost, and rapid development. As a result, systems are expected to be predominantly non-redundant or "single string." However, redundancy is encouraged where appropriate and where resources allow.

The SMA requirements for the LWS Program are structured to accept the increased risk that is inherent in a predominately non-redundant system. A strong parts and materials program, robust reliability and quality programs for hardware and software, and significant reliance on the test program will be key factors in balancing requirements against program cost and complexity constraints. The developer has responsibility and control over development of the deliverable hardware, the integration and test program and delivery to the LWS Project. The LWS Project Office will monitor the developer's activities to provide insight to their compliance with SMA requirements. Emphasis will be focused on those activities that contribute most to product reliability and integrity.

The developer shall refer to this Mission Assurance Requirements (MAR) document in developing their SMA approach, and realistically addressing the costs associated with these tasks. During the definition phase of the mission, the specific implementation details of the developer's safety, reliability and quality assurance program will be negotiated and a mission-specific MAR will be developed. The quality program shall be modeled after ANSI/ASQC Q9001-2000, "Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation, and Servicing".

The developer shall submit a Product Assurance Implementation Plan (PAIP), for LWS Project approval, that details their method of implementing the SMA requirements contained in the mission-specific MAR.

The developer is encouraged to make maximum use of existing practices and procedures in developing and implementing the safety and mission assurance program. The developer may offer an alternate method of meeting the intent of a requirement when such a method is better aligned with the manner in which the total work is to be accomplished, subject to LWS Project approval. The developer shall describe the plans for maintaining adequate internal documentation for all safety, reliability and quality assurance activities and for providing the project with essential deliverable documentation. Upon request, all developer documents utilized on LWS shall be available for LWS Project Office review.

The developer shall direct issues requiring project management attention through the LWS Contracting Officer's Technical Representative (COTR).

The developer shall create a PAIP that provides a comprehensive plan for accomplishing the SMA activities in compliance with the requirements herein. The PAIP shall describe the developers' system for planning, documentation, and controls that will ensure complete traceability through all phases of the manufacturing, assembly, and testing of deliverable items.

The PAIP shall include:

- An overview of the developer's plan for accomplishing the assurance activities required by this MAR.
- Specific and detailed description of how the performance assurance requirements are to be accomplished. Referenced documents that provide the required details shall be submitted with the PAIP.
- The rationale for any planned noncompliance to the MAR including the details of the developer's alternate approach, if any, to meet the specific MAR requirement.

## 1.2 USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

When hardware that was designed, fabricated, or flown on a previous project is considered to have demonstrated compliance with some or all of the requirements of this document such that certain tasks need not be repeated, the developer shall demonstrate how the hardware complies with requirements.

## 1.3 SURVEILLANCE OF THE DEVELOPER

The work activities, operations, and documentation performed by the developer or his suppliers are subject to evaluation, review, audit, and inspection by government-designated representatives from the LWS project, the Government Inspection Agency, or an independent assurance contractor. The LWS project will delegate in-plant responsibilities and authority to those organizations via a letter of delegation or letter of assignment.

The developer shall grant access for NASA and NASA representatives to conduct an assessment or survey upon notice. The developer, upon request, shall provide government assurance representatives with documents, records, and equipment required to perform their assurance and safety activities. The developer shall also provide the government assurance representative(s) with an acceptable work area within developer facilities.

## 1.4 SAFETY AND MISSION ASSURANCE VERIFICATION

The developer shall submit their PAIP for LWS Project review and approval. The LWS Systems Assurance Manager (SAM) will periodically validate the developers' overall SMA program to inform the project office of potential problems or concerns. Upon request, the developer shall provide the LWS project or designated assurance representatives, with assurance and safety documents, and access needed to support these activities, including access to all developer LWS SMA databases.

# Chapter 2. Quality Management System

## 2.0 QUALITY MANAGEMENT SYSTEM

The developer shall implement a Quality Management System (QMS) that is compliant with the minimum requirements of ANSI/ISO/ASQ Q9001:2000 or equivalent. Certificates issued to ISO 9001:1994 will have a maximum validity of 3 years from the publication date of ANSI/ISO/ASQ Q9001:2000. The developer's Quality Manual shall be provided upon request.

## 2.1 SUPPLEMENTAL QUALITY MANAGEMENT SYSTEM REQUIREMENTS

The following requirements supplement ANSI/ISO/ASQ Q9001:2000:

### 2.1.1 Nonconformance Reporting and Corrective Action

The developer shall have a system for identifying and reporting hardware and software nonconformances through a closed loop reporting system; ensuring that positive corrective action is implemented to preclude recurrence and verification of the adequacy of implemented corrective action by audit and test as appropriate. The developer shall provide the LWS Project with documentation describing how nonconforming material is designated, controlled, and segregated from normal production flow. The document shall describe in detail the approval authority for accepting the disposition with government concurrence, and how the documentation is controlled, i.e. Material Review Boards (MRB).

The Nonconformance Reporting and Corrective Action (NRCA) process shall include:

1. Nonconformance detection and reporting procedures;
2. Nonconformance tracking and management procedures;
3. Nonconformance impact assessment and corrective action procedures;
4. Interfaces to the Configuration Management process.

#### 2.1.1.1 Material Review Board

The developer shall inform the LWS Project of MRB meeting schedules and agendas with sufficient advance notice (four hours minimum) to permit LWS project participation. The developer shall provide the LWS Project access to their LWS material discrepancy-reporting database. The LWS Project COTR reserves disapproval rights on MRB decisions.

#### 2.1.1.2 Reporting of Failure

The developer shall report flight hardware failures to the LWS Project beginning with the first "power on application" tests at the component level (or above) of flight hardware; or the first operation of a mechanical item. Reporting shall continue through successful closure by the Failure Review Board (FRB).

Failures shall be reported to the LWS project office within one business day of occurrence. Failure reports documenting the failure and investigation shall be supplied to the LWS Project COTR within 5 business

The developer shall implement a process for Software NRCA that addresses reporting, analyzing, and correcting nonconformances throughout the development life cycle. The developer's QMS shall provide for a corrective action process that tracks every nonconformance to its final disposition. The NRCA process for a software product shall start no later than the establishment of a configuration management baseline that includes the product.

### 2.1.2 Control of Monitoring and Measuring Devices

Testing and Calibration Laboratories shall be compliant with the requirements of ISO 17025 – General Requirements for the Competence of Testing and Calibration Laboratories.

### 2.1.3 Configuration Management

The developer shall perform configuration management (CM) in support of the LWS Project. The developer shall document the CM process in the PAIP or in a separate document submitted to the LWS project. The configuration of deliverable items shall be maintained throughout all phases of assembly and test. Configuration verification shall be performed and documented as assemblies are incorporated into higher-level assemblies and at major project milestones (i.e. pre-environmental test, pre-ship, pre-launch, etc). The CM system shall have a change classification and impact assessment process that results in Class 1 changes being forwarded to the LWS Project for disposition. Class 1 changes are defined as major changes that affect mission requirements, system safety, cost, schedule, and external interfaces. All other changes are considered to be Class ll changes.

Any flight item that is found to be non-compliant with the requirements of the contract Statement Of Work (SOW) or the MAR and is not reworked to be compliant, or is not replaced with a compliant item, shall be dispositioned via a waiver. The developer shall submit Class I waivers to the LWS project office for final approval. Waivers that affect mission requirements, system safety, cost, schedule, and external interfaces are to be processed as Class I. All other waivers are processed as Class ll.

Software CM is further defined in Section 5 of this MAR

## 2.2 GROUND SUPPORT EQUIPMENT

Mechanical and electrical Ground Support Equipment (GSE) and associated software that directly interfaces with flight deliverable items shall be assembled and maintained to the same standards as the deliverable flight items, especially calibration control and configuration management. Parts and materials selection and reporting requirements are excepted as long as deliverable flight item contamination requirements are not compromised. Problem reporting shall begin with the first use of deliverable flight items and shall continue for the duration of the project. The developer PAIP shall address SMA for GSE.

## 2.3 REQUIREMENTS FLOW-DOWN

The developer shall ensure flow-down of technical requirements to all suppliers and establish a process to verify compliance. The developer's Contracts Review and Purchasing processes shall indicate the process for documenting, communicating, and reviewing requirements with sub-tier suppliers to ensure requirements are met.

# Chapter 3. System Safety Requirements

## 3.0 GENERAL REQUIREMENTS

The developer shall implement a system safety program in accordance with contractual and regulatory requirements. The system safety program shall be initiated in the concept phase of design and continue though out all phases of the mission as defined by the applicable requirements documents listed below. The developer shall implement a program that provides for early identification and control of hazards during design, fabrication, test transportation, and ground activities.

The developer shall plan and implement a system safety program that accomplishes the following:

a. Identifies and controls hazards to personnel, facilities, support equipment, and the flight system during all stages of project development. The program shall address hazards in the flight hardware, associated software, ground support equipment, and support facilities;

b. Meets the system safety requirements of EWR 127-1 "Range Safety Requirements Eastern and Western Range" and KHB 1710.2D, "Kennedy Space Center Safety Practices Handbook" for launches from KSC;

c. Meets the baseline industrial safety requirements of the institution, EWR 127-1, and any special contractually imposed mission unique obligations.

## 3.1 SYSTEM SAFETY IMPLEMENTATION PLAN

The developer shall prepare a System Safety Implementation Plan (SSIP), that describes the systems safety implementation process for each flight mission which includes analysis, reduction, and/or elimination of hazards that may cause the following:

a. Loss of life or injury/illness to personnel;

b. Damage to or loss of equipment or property (including software);

c. Unexpected or collateral damage as a result of tests;

d. Failure of mission;

e. Loss of system availability;

f. Damage to the environment.

## 3.2 SAFETY PACKAGE

The developer shall submit a Missile System Prelaunch Safety Package (MSPSP) consistent with the design maturity of the program at each of the phase C/D independent reviews, up to and including the Pre-shipment Review. The contents of each package shall be consistent with the requirements of the Eastern/Western Test Range requirements of EWR 127-1 and NASA safety KHB 1710.2D requirements.

Early in the design phase and continuing through the development effort, the developer shall identify the ground operations hazards associated with the flight system, ground support equipment, and their interfaces. The MSPSP shall include, as a minimum, a detailed description of the payload design sufficient to support hazard analysis

## 3.3 SUPPORT FOR SAFETY WORKING GROUP MEETINGS

The developer shall provide technical support to the LWS Project for safety working group meetings, Technical Interface Meetings, and technical reviews, when necessary.

## 3.4 ORBITAL DEBRIS ASSESSMENT

The developer shall supply an Orbital Debris Assessment or the information required to produce the assessment consistent with NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris. The developer shall develop the debris assessment in accordance with the NASA policy NPD 8710.3.

## 3.5 SOFTWARE SAFETY ASSURANCE

The developer shall conduct a software safety program to identify and mitigate safety-critical software products. If any software component is identified as safety-critical, the developer shall conduct a software safety program on that component in compliance with NASA-STD-8719.13A "NASA Software Safety Standard".

The software safety program shall ensure that:

1. Safety-related deficiencies in specifications and design are identified and corrected;
2. Software design incorporates positive measures to enhance the safety of the system;.
3. Software safety is included as an agenda item for formal reviews.

The software safety process shall include the following activities:

1. Determination of the safety criticality for each software component;
2. Analysis of the consistency, completeness, correctness, and testability of safety requirements;
3. Analysis of design and code to ensure implementation of safety-critical requirements;
4. Analysis of changes for safety impact.

# Chapter 4. Risk Management Requirements

## 4.0 GENERAL RISK MANAGEMENT REQUIREMENTS

The developer shall apply a risk management program to the development of all software and hardware products and processes (flight and ground). The developer shall identify, analyze, track, control risks and plan mitigation actions.

The developer shall:

a. Identify and document reliability and quality risks before they become problems;

b. Evaluate, classify, and prioritize all identified reliability and quality risks;

c. Develop and implement risk mitigation strategies and actions and assign appropriate resources;

d. Track risks being mitigated; capture risk attributes and mitigation information by collecting data; establish performance metrics; and examine trends, deviations, and anomalies;

e. Control risks by performing risk close-out, re-planning, contingency planning, or continued tracking and execution of the current plan;

f. Communicate and document (via the risk recording, reporting, and monitoring system) risk information to ensure it is conveyed between all levels of the project;

g. Report on outstanding risk items at all management and design reviews.

## 4.1 RISK MANAGEMENT PLAN

The developer shall develop a Risk Management Plan for the project for which they are responsible. The plan shall be developed in compliance with NPG 7120.5A, "NASA Program and Project Management Processes and Requirements". The plan shall include risks associated with hardware (technical challenges, new technology qualification, etc.), software, system safety, performance, and programmatic risks (cost and schedule). The plan shall identify the tools and techniques to be used to manage risks. The risk areas that are identified shall be addressed at peer reviews and at government reviews. The developer's plan shall address the risk areas to ensure adequate mitigation steps are in place.

## 4.2 RELIABILITY REQUIREMENTS

Early in the design process the developer shall identify specific reliability concerns and the steps being taken to mitigate them. Reliability analyses of the design shall be conducted in accordance with the following sections. These analyses shall be reviewed with the LWS COTR as they are developed and iterated, and reported in detail at the phase C/D formal design reviews.

The Reliability program shall:

a. Use Probabilistic Risk Assessments (PRA) and Fault Tree Analyses (FTA) to assess, manage, and, if necessary, quantitatively assess the need to reduce program risk;

b. Demonstrate that redundant functions, including alternative paths and work-arounds, are independent to the extent practicable;

c. Demonstrate that stress applied to parts is not excessive;

h. Ensure that the design permits easy replacement of parts and components and that redundant paths are easily monitored.

## 4.3 RELIABILITY ANALYSES

The developer shall perform reliability analyses concurrently with design so that identified problem areas can be addressed and corrective action taken (if required) in a timely manner.

### 4.3.1 Failure Modes and Effects Analysis and Critical Items List

The developer shall perform a Failure Modes and Effects Analysis (FMEA) early in the design phase to identify system design problems. As additional design information becomes available the developer shall refine the FMEA. Failure modes shall be assessed at the component interface level. Each failure mode shall be assessed for the effect at that level of analysis, the next higher level and upward. The failure mode shall be assigned a severity category based on the most severe effect caused by a failure. Mission phases (e.g., launch, deployment, on-orbit operation, and retrieval) shall be addressed in the analysis.

Severity categories shall be determined in accordance with Table 4-1:

**TABLE 4-1. SEVERITY CATEGORIES**

| Category | Severity | Description |
|---|---|---|
| 1 | Catastrophic | Failure modes that could result in serious injury, loss of life (flight or ground personnel), or loss of launch vehicle. |
| 1R | | Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1 effects. |
| 1S | | Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and lead to Severity Category 1 consequences. |
| 2 | Critical | Failure modes that could result in loss of one or more mission objectives as defined by the GSFC project office. |
| 2R | | Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed. |
| 3 | Significant | Failure modes that could cause degradation to mission objectives. |
| 4 | Minor | Failure modes that could result in insignificant or no loss to mission objectives |

The FMEA shall analyze redundancies to ensure that redundant paths are isolated or protected such that any single failure that causes the loss of a functional path will not affect the other functional path(s) or the capability to switch operation to that redundant path.

All failure modes that are assigned to Severity Categories 1, 1R, 1S, and 2, shall be itemized on a Critical Items List (CIL) and maintained with the FMEA report. Rationale for retaining the items will be included on the CIL. The FMEA and CIL shall be submitted to the LWS project in accordance with the SOW. Results of the FMEA and the CIL shall be presented at all design reviews starting with the Preliminary Design Review. The presentations shall include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

### 4.3.2 Probabilistic Risk Assessment And Fault Tree Analysis

The developer shall use Probabilistic Risk Assessment (PRA) and Fault Tree Analysis (FTA) as part of the project's risk management and reliability programs. The developer shall include specific results in their Critical Design Review (CDR) and post-CDR reviews. The developer shall make the PRA and FTA available to the LWS project upon request.

#### 4.3.2.1 Fault Tree Analysis

The developer shall perform FTAs that address both mission failures and degraded modes of operation in accordance with the SOW. Beginning with each undesired state (mission failure or degraded mission), the fault tree shall be expanded to include all credible combinations of events, faults and environments that could lead to that undesired state. Component hardware/software failures, external hardware/software failures, and human factors shall be considered in the analysis.

#### 4.3.2.2 Probabilistic Risk Assessment (PRA)

The developer shall perform PRAs that include an analysis of the probability (or frequency) of occurrence of a consequence of interest, and the magnitude of that consequence, including assessment and display of uncertainties. PRA shall be implemented as part of the systems engineering process, based on comprehensive systems analysis with analytical support, and repeated periodically as the design matures and new data become available.

### 4.3.3 Parts Stress Analyses

The developer shall perform stress analyses on Electrical, Electronic, and Electromechanical (EEE) parts and devices, as applied in circuits within each component for conformance with the derating policy of MIL-STD-975 and the GSFC PPL-21 (Preferred Parts List). The analyses shall be performed at the most stressful part-level parameter values that can result from the specified performance and environmental requirements on the assembly or component. The analyses shall be performed in close coordination with the packaging reviews and shall be required input data for component-level design reviews. The analyses shall be documented, and justification shall be included for all applications that do not meet the derating criteria.

### 4.3.4 Worst Case Analyses

The developer shall perform worst-case analyses for critical parameters that are subject to variations that could

a. Evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions

b. Identify the elements of the design which are the greatest detractors of system reliability

c. Identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations

d. Assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable

e. Evaluate the impact of proposed engineering change and waiver requests on reliability

The developer shall describe in their assessments the level of detail of a model suitable for performing the intended functions enumerated above. The assessments and updates shall be submitted to the LWS Project for information in accordance with the contract SOW. The results of any reliability assessment shall be reported at PDR and CDR. The presentations shall include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

### 4.3.6 Software Reliability

The developer shall develop a software reliability program concentrated on the tolerance of minor defects and the complete removal of critical defects. The software reliability program shall monitor and control defect removal, field performance, and include a model to predict the bug removal rate or number of bugs remaining based on testing, running time, or bug count. The software reliability model may be time domain (related to the number of bugs at a given time during development), data domain (estimated by running the program for a subset of input data), axiomatic (based on laws/rules applied during the programming process), or other methods resulting from input data sets, logic paths, or other methods.

The developer shall document actions to verify that the software design and software engineering techniques improve the duration or probability of failure free performance and ensure repeatability of the software.

## 4.4 RELIABILITY ANALYSIS OF TEST DATA

The developer shall fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

### 4.4.1 Trend Analyses

The developer shall perform trend analyses to the component level to track measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring shall be accomplished within the normal test framework (i.e., during functional tests, environmental tests, etc). The developer shall establish a system for recording and analyzing the parameters as well as any changes from the first observed value even if the levels are within specified limits. A list of parameters to be monitored and the trend analysis reports shall be available to the LWS Project upon request. Trend analysis data shall be reviewed with the mission operational personnel prior to launch, and the mission operational personnel shall continue recording trends throughout mission life for early detection of possible mission failure tendencies.

### 4.4.2 Analysis of Test Results

required life when fabrication, test, storage, and mission operation are combined. The contractor shall maintain a list of limited-life items which shall include the following data elements: item, expected life, required life, duty cycle, rationale for selection and effect on mission parameters. An item's useful life period begins with either (1) its fabrication or (2) installation into flight hardware, as appropriate, and ends when the orbital mission is completed.

The list of limited-life items should include selected structures, thermal control surfaces, solar arrays, and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue should be used to identify limited-life thermal control surfaces and structure items. Mechanisms such as batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators, and scan devices should be included when aging, wear, fatigue and lubricant degradation limit their life. Records shall be maintained that allow evaluation of the cumulative stress (time and/or cycles) for limited-life items, starting when useful life is initiated and indicating the project activity that stresses the items. The use of an item whose expected life is less than its mission design life must be approved by the LWS Project by means of a program waiver.

A record tracking the pre-launch cumulative operating times or cycles on life-limited items shall be devised and implemented. The record shall begin when useful life is initiated and shall record the activity or operation stressing each item. Any items to be used for which the expected life is less than the mission design life must be approved by the LWS COTR via a waiver.

## 4.6 CONTROL OF SUBDEVELOPERS AND SUPPLIERS

The developer shall ensure that system elements obtained from subdevelopers and suppliers will meet the pertinent project reliability requirements. All subcontracts shall include provisions for review and evaluation of the subdevelopers' and suppliers' reliability efforts by the prime developer at the prime developer's discretion, and by the LWS Project at its discretion.

The developer shall tailor the reliability requirements of this document in hardware and software subcontracts for the project and shall exercise necessary surveillance to ensure that subdevelopers' and suppliers' reliability efforts are consistent with overall system requirements. The developer shall, as a result of this tailoring:

- Incorporate quantitative reliability requirements in subcontracted equipment specifications;
- Assure that subdevelopers have reliability programs that are compatible with the overall program;
- Review subdevelopers' assessments and analyses for accuracy and correctness of approach;
- Review subdevelopers' test plans, procedures, and reports for correctness of approach and test details;
- Attend and participate in subdevelopers' design reviews.
- Ensure that subdevelopers comply with the applicable system reliability requirements during the project operational phase.

# Chapter 5. Software Assurance Requirements

## 5.0 GENERAL REQUIREMENTS

The developer shall implement a Quality Management System (QMS) that addresses software development and software assurance functions. The developer shall implement a QMS that is compliant to the minimum requirements of ANSI/ISO/ASQ 9001:2000 or equivalent. The QMS shall be applied to software and firmware developed under this contract. The management program shall be described in a Software Development Plan.

### 5.0.1 Management Review

The developer's management process shall provide for a series of developer-presented formal reviews chaired by a government review panel. The formal review program shall consist of a Software Requirements Review (SRR), a Preliminary Design Review (PDR), a Critical Design Review (CDR), a Test Readiness Review (TRR), and an Acceptance Review. The developer shall record minutes and action items during each review. The developer shall respond to and follow through to closure actions assigned by the project as a result of each review.

Records of reviews not required by the contract but conducted by the developer in accordance with the developer's QMS, shall be available for review by the LWS Project upon request.

### 5.0.2 Peer Review

The developer shall implement a program of engineering working-level reviews (peer reviews) throughout the development life cycle to identify and resolve concerns prior to formal, system level reviews.

Topics that shall be addressed in the peer reviews include:

1. Design verification;
2. Coding;
3. Analyses and studies;
4. Safety;
5. Risk assessment, resolution and contingency plans;
6. Procurements;
7. Configuration management;
8. Testability and test planning, including test anomalies and resolution.

## 5.1 SOFTWARE QUALITY ASSURANCE

The developer shall plan, document and implement a software assurance program for software development activities. The developer shall identify the Software Quality Manager responsible for project software quality assurance. The software assurance program shall:

1. Ensure that assurance requirements are documented and satisfied throughout all phases of the development life cycle;

### 5.1.2 Process Monitoring

The developer's quality assurance program shall ensure:

1. Standards and procedures for management, engineering and assurance activities are specified;
2. Management, engineering, and assurance personnel adhere to specified standards and procedures;
3. All plans (e.g., configuration management, risk management, etc.) are completed and implemented according to specified standards and procedures.

The developer's quality assurance activities shall include:

1. Evaluation of specified standards and procedures;
2. Audits of management, engineering, and assurance processes;
3. Reviews of project documentation including reports, schedules, and records;
4. Monitoring of formal inspections and formal reviews;
5. Monitoring/witnessing of formal and acceptance-level software testing.

## 5.2 SOFTWARE QUALITY ENGINEERING

The developer shall implement a system for Software Quality Engineering (SQE) that ensures requirements for reliability, maintainability, usability and safety are built into the products produced at each phase of the software development life cycle.

The SQE program shall ensure that:

1. All quality requirements are defined in a manner that is measurable or otherwise verifiable;
2. Quality requirements are considered during design of the software;
3. The software is tested/measured to verify compliance with quality requirements.

The SQE program shall include the following activities:

1. Analysis, identification, and detailed definition of all quality requirements;
2. Quality engineering evaluations of standards, design, and code;
3. Collection and analysis of metric data pertaining to quality requirements.

### 5.2.1 Software Configuration Management

The developer shall maintain a Software Configuration Management (SCM) system that provides control of changes to software products, beginning in the testing phase and continuing until government acceptance. SCM control shall be implemented in the development cycle no later than immediately prior to the first test for which test results must be reported to the NASA project office.

The developer shall ensure the configuration management system addresses baseline control, configuration identification, configuration control, configuration status accounting and configuration authentication. The developer shall describe the SCM system in a Software Configuration Management Plan.

### 5.3.1 Verification and Validation Activities

V&V activities shall be performed during each phase of the software life cycle and shall include the following:

1. Analysis of system and software requirements allocation, verifiability, testability, completeness, and consistency (including analysis of test requirements);
2. Design and code analysis including design completeness and correctness;
3. Interface analysis (requirements and design levels);
4. Formal Inspections;
5. Formal Reviews (phase transition reviews);
6. Test planning, performance, and reporting.

### 5.3.2 Independent Verification and Validation

The developer shall provide access to information requested by the LWS Project for the NASA Independent Verification and Validation (IV&V) effort. Wherever possible, the developer shall permit electronic access to the required information. The developer shall allow NASA IV&V review and participation before final product delivery to NASA.

## 5.4 GOVERNMENT FURNISHED EQUIPMENT, EXISTING AND PURCHASED SOFTWARE AND FIRMWARE

If the developer will be provided software as government-furnished equipment (GFE), or will use existing or purchased software and firmware, the developer shall ensure that the software and firmware meets the functional, performance, and interface requirements placed upon it. The developer shall ensure that the software and firmware meets applicable standards, including those for design, code, and documentation, or shall secure a LWS Project waiver to those standards. Any significant modification to any piece of the existing software shall be subject to the provisions of the developer's QMS and the provisions of this document. A significant modification is defined as the change of twenty percent of the lines of code in the software.

# Chapter 6. Technical Review Requirements

## 6.0 GENERAL REQUIREMENTS

The developer shall provide support for a formal review program chaired by GSFC that ensures that the LWS Mission Assurance review program:

1. Assures that the spacecraft, instrument(s) and supporting designs are consistent with the LWS Mission Requirements Document;
2. Assures that the characteristics of the systems are carefully examined to develop the best approach consistent with existing constraints and available resources;
3. Provides a means of periodic evaluation of the hardware, software, and ground support development;
4. Assures that end-item deliverables (systems and subsystems) meet the LWS requirements for performance, schedule and cost.

The developer shall provide the following formal system level reviews:

- Preliminary Design Review;
- Critical Design Review;
- Mission Operations Review;
- Pre-Environmental Review;
- Flight Operations Review;
- Pre-Ship Review;
- Flight Readiness Review.

The developer shall support the series of comprehensive system-level design reviews that are conducted by the GSFC Systems Review Office (SRO). The reviews cover all aspects of flight and ground hardware, software, and operations for which the developer has responsibility. For each specified system-level review conducted by the GSFC SRO, the developer shall:

a. Develop and organize material for oral presentation to the LWS government review team. Copies of the presentation material will be available at each review.

b. Support splinter review meetings resulting from the major review;

c. Produce written responses to recommendations and action items resulting from the review;

d. Summarize, as appropriate, the results of the developer reviews at the component and subsystem level.

## 6.1 PHASE B REVIEWS

Phase B formally begins with the signed contract agreement for the mission and ends with formal confirmation for

## 6.2 PHASE C/D REVIEWS

Critical Design Review (CDR) – This review occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. The developer shall emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing.

Mission Operations Review (MOR) – This Mission-oriented review occurs before significant integration and test (I&T) of the flight systems and ground systems. The developer shall present the status of the system components, including the ground system, network operations, the operational interfaces with the flight system, and orbital operations plans.

Pre-Environmental Review (PER) – This review occurs prior to the start of environmental testing of the flight instrument. The developer shall present the readiness of the flight hardware and software, and facilities for system level test and evaluate the environmental test plans.

Flight Operations Review (FOR) – The developer shall emphasize the final orbital operations plans as well as the compatibility of the flight components with ground support equipment and the ground network, including summary results of the network compatibility tests.

Pre-Shipment Review (PSR) – This review shall take place prior to shipment of the observatory to the launch site. The developer shall present evidence to show that testing has been completed with no unacceptable open issues and will evaluate the readiness of the hardware and software for flight. The developer shall address the testing on flight hardware and software, verification and documentation of the hardware and software configuration, identification of outstanding safety risks, disposition of waivers/deviations/open issues, compatibility of spacecraft and ground support equipment, and orbital operations plans

Flight Readiness Review (FRR) – This review will be conducted at the launch facility to verify overall readiness of flight hardware and software, and ground and launch support resources to achieve the mission flight objectives.

## 6.3 PEER REVIEWS

Engineering peer reviews of component and subsystem hardware/software chaired by the developer shall occur during all phases of the project life cycle. These reviews are expected to be the most detailed of the LWS reviews. It is the intent of the peer reviews that participants generate a detailed understanding of the component and subsystem designs' ability to meet higher level system and mission requirements. Effective peer reviews will enable significant streamlining of the content of higher-level formal reviews. To promote continuity of the whole review program, the developer shall allow notify the COTR of the peer review schedule to allow participation by the GSFC Systems Review Office and the GSFC LWS Project technical experts at the peer review sessions.

## 6.4 REVIEW ACTION ITEM TRACKING

The developer shall implement a system for tracking the status and resolution of Action Items initiated during peer and formal reviews whose status shall be reported at the formal reviews. Action Items shall be assigned unique control numbers that identify the item under review and the review type. The numbering/tracking system shall be capable of differentiating Action Items of any specific system review from all other system reviews.

# Chapter 7. Design Verification Requirements

## 7.0 GENERAL REQUIREMENTS

The developer shall conduct a system performance verification program covering the component through Instrument or Observatory levels. The developer shall document the overall verification plan, implementation, and results to ensure that the spacecraft and instruments meet the specified mission requirements, and to provide traceability from mission requirements through launch and on-orbit capability. The program shall consist of a series of functional demonstrations, analytical investigations, physical property measurements, and environmental tests that simulate the environments encountered during handling and transportation, pre-launch, launch, and on-orbit. The developer shall maintain as-run verification procedures, including all test and analysis data.

All flight hardware and software shall undergo qualification to demonstrate compliance with the requirements of this section. In addition, all other hardware (flight follow-on, spare and re-flight) shall undergo acceptance in accordance with the requirements of this section.

The Verification Program shall begin with functional testing at the component level of assembly. It shall continue through functional and environmental testing at the component, subsystem, instrument, spacecraft and observatory levels of assembly, supported by appropriate analysis. The program shall conclude with end-to-end testing of the entire operational hardware/software system at the observatory level including the instruments, the ground control center, and the appropriate network elements.

## 7.1 REQUIREMENTS VERIFICATION MATRIX

The developer shall provide adequate documentation to demonstrate compliance with all performance requirements identified in the contract SOW. The developer shall have a Requirements Verification Matrix or equivalent system that shows the flow-down of all requirements and the methods of verification. The Requirements Verification Matrix and supporting documentation shall provide the following information:

- Systems Performance Validation Plan flow-down;
- Basis for verification method (test, analysis, similarity, heritage, etc.);
- Dates accomplished with name and signature of person performing the action;
- Dates verified with name and signature of person verifying performance;
- Definition of specific environments for each requirement;
- Tracking of requirements verified against those planned;
- Detailed supporting documentation of compliance with each requirement.

## 7.2 ENVIRONMENTAL TEST PROGRAM

The developer shall conduct an environmental test program for flight hardware sufficient to demonstrate design qualification, acceptance, and to test for workmanship. Functional testing shall be performed before, during, and

Prototype and protoflight hardware shall undergo appropriate qualification tests to demonstrate compliance with the design requirements. Flight, flight spare, follow-on, and re-flight hardware shall undergo flight-like acceptance test levels to verify acceptable assembly workmanship.

The following environmental exposures are required as a baseline for LWS Observatories and Instruments:

Components:

Sine Vibration, Random Vibration, Strength, EMI/EMC, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployment shall be performed. Comprehensive Performance Tests (CPTs) shall be part of the verification program at these levels of assembly.

Observatory and Instrument Levels:

Strength (static or quasi-static), Low level (Pogo) Sine Vibration, Random Vibration, Acoustics, Mechanical Shock, EMI/EMC, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployment shall be performed.

Repeated functional tests should be used to demonstrate the growing maturity of the instruments or spacecraft subsystems, perform trending analysis, and to baseline performance status before each environmental test. CPT demonstrations shall be performed to verify full mission hardware compliance, compatibility, and operability; and to perform trending analysis.

## 7.3 END-TO-END TEST

Prior to the PSR, the developer shall perform an end-to-end compatibility test to demonstrate the ground system capability to communicate with the observatory (up-link and down-link) via the ground to space network. Simulated normal orbital mission scenarios encompassing launch, systems turn-on, housekeeping, command/control, and stabilization/pointing shall be demonstrated, including the collecting, processing, and archiving of science data. Observatory immunity to erroneous commands, autonomous safe-hold, and simulated anomaly recovery operations shall also be demonstrated.

## 7.4 DEMONSTRATION OF FAILURE-FREE OPERATION

At the conclusion of the verification program, each LWS Observatory or Instrument shall have demonstrated a period of 100 hours of consecutive failure-free operation in its simulated mission orbital environment prior to shipment to the launch site. The demonstration may be performed at the subsystem level when the time period of demonstration cannot be practically accomplished at the system level of assembly. Major hardware changes during or after the failure-free period will invalidate any previous demonstration.

# CHAPTER 8. Workmanship Standards and Processes

## 8.0 GENERAL REQUIREMENTS

The developer shall plan and implement a Workmanship Program to assure that all electronic packaging technologies, processes, and workmanship activities selected and applied meet mission objectives for quality and reliability.

## 8.1 APPLICABLE DOCUMENTS*

Conformal Coating and Staking: NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies;

Soldering – Flight, Surface Mount Technology: NASA-STD-8739.2, Surface Mount Technology;

Soldering – Flight, Manual (hand): NASA-STD-8739.3, Soldered Electrical Connections;

Soldering – Ground Systems: IPC/EIA J-STD-001C, Requirements for Soldered Electrical and Electronic Assemblies;

Electronic Assemblies – Ground Systems: IPC-A-610C, Acceptability of Electronic Assemblies;

Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring;

Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation;

Electrostatic Discharge Control (ESD): NASA-STD-8739.7, Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices);

Printed Wiring Board (PWB) Design:

- IPC-2221, Generic Standard on Printed Board Design
- IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards
- IPC-2223, Sectional Design Standard for Flexible Printed Boards;

Printed Wiring Board Manufacture:

- IPC A-600, Acceptability of Printed Boards
- IPC-6011, Generic Performance Specification for Printed Boards
- IPC-6012, Qualification and Performance Specification for Rigid Printed Boards
  - Flight Applications – Supplemented with: GSFC/S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
- IPC-6013, Qualification and Performance Specification for Flexible Printed Boards.

*current status and/or any application notes for these standards can be obtained at URL http://standards.nasa.gov

## 8.2 DESIGN

#### 8.2.2 Assemblies

The design considerations listed in the NASA workmanship standards listed above should be incorporated to the extent practical.

#### 8.2.3 Ground Systems That Interface With Space Flight Hardware

Ground system assemblies that interface directly with space flight hardware shall be designed and fabricated using space flight parts, materials, and processes for any portion of an assembly that mates with the flight hardware; or that will reside with the space flight hardware in environmental chambers or other test facilities that simulate a space flight environment (e.g., connectors, test cables, etc.).

### 8.3 WORKMANSHIP REQUIREMENTS

#### 8.3.1 Training and Certification

All personnel working on deliverable hardware shall be certified as having completed the required training, appropriate to their involvement, as defined in the above standards.

#### 8.3.2 Flight and Harsh Environment Ground Systems Workmanship

##### 8.3.2.1 Printed Wiring Boards

Printed Wiring Boards (PWBs) shall be manufactured in accordance with the Class 3 Requirements in the above referenced PWB manufacturing standards. The developer shall provide printed wiring board (PWB) coupons to the LWS Project, or to a NASA-approved laboratory for evaluation. PWB coupon approval shall be obtained prior to population of flight PWBs. The developer may have the coupons evaluated at an alternate laboratory if written approval is obtained from the LWS Project office in advance. If an approved alternate laboratory is used, delivery of the test reports to the LWS Project office is required.

##### 8.3.2.2 Assemblies

Assemblies shall be fabricated using the appropriate workmanship standards listed above (i.e., NASA-STD-8739.3 for hand soldering; NASA-STD-8739.4 for crimping/cabling; NASA-STD-8739.5 for fiber optic termination and installation; etc.).

#### 8.3.3 Ground Systems (non-flight) Workmanship

##### 8.3.3.1 Printed Wiring Boards

PWBs shall be manufactured in accordance with the Class 2 Requirements in the above referenced PWB manufacturing standards.

##### 8.3.3.2 Assemblies

Assemblies shall be fabricated using the Class 2 Requirements of J-STD-001C and IPC-A-610C, and NASA-STD-8739.7. If any conflicts between J-STD-001C and IPC-A-610C are encountered, the requirements in J-STD-001C shall take precedence.

## 8.4 NEW OR ADVANCED PACKAGING TECHNOLOGIES

New and/or existing advanced packaging technologies (e.g., multi-chip modules (MCMs), stacked memories, chip on board, ball grid array (BGA), etc.) shall be reviewed, approved by the project Parts Control Board and included in the Project Approved Parts List (PAPL).

## 8.5 HARDWARE HANDLING

The handling of flight hardware shall be performed by designated personnel in accordance with approved procedures that address cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., antistatic film materials), and purging. Procedures for the control of contamination shall be implemented in all phases of assembly and test. All personnel working on flight hardware shall be certified as having completed the required certifications prior to handling any flight hardware. This includes, but is not limited to, the aforementioned workmanship, design and ESD awareness courses.

## 8.6 ELECTROSTATIC DISCHARGE CONTROL REQUIREMENTS

The developer shall document and implement an ESD Control Program in accordance with NASA-STD-8739.7 suitable to protect the most sensitive components used in the project. At a minimum, the ESD Control Program shall address training, protected work area procedures and verification schedules, packaging, facility maintenance, storage, and shipping.

All personnel who manufacture, inspect, test, otherwise process electronic hardware, or require unescorted access into ESD protected areas shall be certified as having completed the required training, appropriate to their involvement, as defined in NASA-STD-8739.7 prior to handling any electronic hardware.

Electronic hardware shall be manufactured, inspected, tested, or otherwise processed only at designated ESD protective work areas. These work areas shall be verified on a regular schedule as identified in the developer's ESD Control Program.

Electronic hardware shall be properly packaged in ESD protective packaging at all times when not actively being manufactured, inspected, tested, or otherwise processed.

# Chapter 9. Parts Requirements

## 9.0 GENERAL

The developer shall plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability.

The developer shall prepare a Parts Control Plan (PCP) describing the approach and methodology for implementing the Parts Control Program. The PCP will also define the developer's criteria for parts selection and approval based on the guidelines of this section. The PCP will be made a part of the proposal for review in accordance with contract delivery requirements.

## 9.1 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS

All part commodities identified in the NASA Parts Selection List are considered EEE parts and will be subjected to the requirements set forth in this section. Custom or advanced technology devices such as custom hybrid microcircuits, detectors, Application Specific Integrated Circuits (ASIC), and Multi-Chip Modules (MCM) shall also be subject to parts control appropriate for the individual technology.

### 9.1.1 Parts Control Board

The developer shall establish a Parts Control Board (PCB) or a similar documented system to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. The PCB shall be responsible for the review and approval of all parts for conformance to established criteria, and for developing and maintaining a Parts Identification List (PIL). In addition, the PCB shall be responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions. PCB operating procedures shall be included as part of the PCP.

#### 9.1.1.1 PCB Meetings

PCB meetings shall be convened on a regular basis or as needed. GSFC may participate in PCB meetings and shall be notified in advance of all upcoming meetings. If participating, GSFC shall have voting rights at PCB meetings. The developer will maintain meeting minutes or records to document all decisions made and a copy provided to GSFC within three days of convening the meeting. PCB activities may be audited by GSFC on a periodic basis to assess conformance to the developer's PCP.

### 9.1.2 Parts Selection and Processing

All parts shall be selected and processed in accordance with the GSFC 311-INST-001 "Instructions for EEE Parts Selection, Screening and Qualification". All application notes in 311-INST-001 will apply. If the parts to be used on the EDU are procured by methods 1 through 4 of GSFC 311-INST-001, full paperwork and documentation (i.e. pedigree) are not required. Parts shall be procured to Class 1 unless otherwise justified and approved by GSFC in accordance with the reliability program. These requirements will then become the established criteria for parts selection, testing, and approval for the duration of the project, and will be documented in the PCP. Parts selected from the NASA Parts Selection List, MIL-STD-975, and the GSFC Preferred Parts List (PPL-21) are considered to have met all criteria of 311-INST-001 for the appropriate parts quality level, and may be approved by the PCB provided all mission application requirements (performance, de-rating, radiation, etc.) are met.

### 9.1.3 De-rating

All EEE parts shall be used in accordance with the de-rating guidelines of the NASA Preferred Parts List (PPL-21). The developer's de-rating policy may be used in place of the NASA Parts Selection List guidelines and will be submitted with the PCP. The developer shall maintain documentation on parts de-rating analysis and shall make it available for GSFC review.

### 9.1.4 Radiation Hardness

All parts shall be selected to meet their intended application in the predicted mission radiation environment. The radiation environment consists of two separate effects, those of total ionizing dose and single-event effects. The developer shall document the analysis for each part with respect to both effects. The possibility of displacement damage shall also be considered for parts susceptible to this effect.

### 9.1.5 Verification Testing

Verification of screening or qualification tests by re-testing is not required unless deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. If required, testing shall be in accordance with 311-INST-001 as determined by the PCB. The developer, however, shall be responsible for the performance of supplier audits, surveys, source inspections, witnessing of tests, and/or data review to verify conformance to established requirements.

### 9.1.6 Destructive Physical Analysis

A sample of each lot date code of microcircuits, hybrid microcircuits, and semiconductor devices shall be subjected to a Destructive Physical Analysis (DPA). All other parts may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. DPA tests, procedures, sample size and criteria shall be as specified in GSFC specification S-311-M-70, Destructive Physical Analysis. Developer's procedures for DPA may be used in place of S-311-M-70 and shall be submitted with the PCP. Variation to the DPA sample size requirements, due to part complexity, availability or cost, shall be determined and approved by the PCB on a case-by-case basis.

### 9.1.7 Parts Age Control

Parts drawn from controlled storage after 5 years from the date of the last full screen shall be subjected to a full 100 percent re-screen and sample DPA. Alternative test plans may be used as determined and approved by the PCB on a case-by case basis. Parts over 10 years from the date of the last full screen or stored in other than controlled conditions where they are exposed to the elements or sources of contamination shall be submitted to the PCB for approval prior to use.

## 9.2 <u>PARTS LISTS</u>

The developer shall create and maintain Parts Identification List (PIL) for the duration of the project. The PCB shall assure standardization and the maximum use of parts listed in the PIL. An As-Built Parts List (ABPL) shall also be prepared and submitted to GSFC in accordance with the contract delivery requirements. The ABPL is generally the final PIL with additional as-built information, such as parts manufacturers and lot date code.

Each parts list shall be a composite of the parts selections for each circuit design in the component, including EEE

(e) Quantity issued/used;

(f) Serial Number;

(g) Order Type;

(h) P.O. Number;

(i) Name or Commercial and Government Entity (CAGE) Code of the part manufacturer;

(j) Manufacturing lot date code;

(k) Vendor ID;

(l) System used;

(m) Part specification control drawing number;

(n) Common designator or generic number;

(o) Drawing number of component to which the list pertains.

## 9.3 ALERTS

The developer shall be responsible for review and disposition of Government Industry Data Exchange Program (GIDEP) Alerts for applicability to the parts proposed for use. In addition, any NASA Alerts and Advisories provided to the developer by GSFC shall be reviewed and dispositioned. Alert applicability, impact, and corrective actions shall be documented and be made available for GSFC review.

# Chapter 10. MATERIALS, PROCESSES AND LUBRICATION REQUIREMENTS

## 10.0 GENERAL REQUIREMENTS

The developer shall implement a comprehensive Materials and Processes Plan beginning at the design stage of the hardware. The plan shall help ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials, processing and lubricants employed to meet the operational requirements for the LWS project. Materials and lubrication assurance approval is required for each usage or application in space-flight hardware. Materials selection shall be in accordance with the specific project performance requirements and as defined below.

## 10.1 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the developer shall, when selecting materials and lubricants, consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxicity, flammability and fracture toughness, as well as the properties required by each material usage or application.

### 10.1.1 Materials Identification List

The contractor shall maintain a Materials Identification List (MIL) of all materials planned for use in flight hardware, regardless of their approval status. The initial MIL and subsequent updates shall be submitted to GSFC in accordance with the contract delivery requirements. An As-Built Materials List (ABML) shall also be prepared and submitted to GSFC in accordance with the contract delivery requirements. The ABML is generally the final MIL with additional as-built information such as materials manufacturers.

The contractor shall provide information for Polymeric Materials and Composites usage as indicated in Figure 10-3; an Inorganic Materials and Composites Usage List as indicated in Figure 10-4, a Lubrication Usage List as indicated in Figure 10-5, and a Materials Process Utilization List as indicated in Figure 10-6.

### 10.1.2 Compliant Materials

The developer shall use compliant materials in the fabrication of flight hardware to the extent practicable.

In order to be compliant, a material must be used in a conventional application and meet the applicable selection criteria:

- Hazardous materials requirements, including flammability, toxicity and compatibility as specified in Eastern and Western Range 127-1 Range Safety Requirements, Sections 3.10 and 3.12 and NASA-STD-6001;

- Vacuum Outgassing requirements as defined below;

- Stress corrosion cracking requirements as defined in MSFC-SPEC-522.

### 10.1.3 Vacuum Outgassing

Material vacuum outgassing shall be determined in accordance with ASTM E-595. In general, a material is qualified on a product-by-product basis. However, GSFC may require lot testing of any material for which lot variation is suspected. In such cases, material approval is contingent upon lot testing. Only materials that have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10% shall be approved for use in a vacuum environment unless application considerations listed on a MUA, dictate otherwise.

### 10.1.4 Non-compliant Materials

A material that does not meet the requirements of the applicable selection criteria above, or meets the requirements above but is used in an unconventional application, shall be considered to be a non-compliant material. The proposed use of a non-compliant material requires that a Materials Usage Agreement (MUA) and/or a Stress Corrosion Evaluation Form (Figure 10-2) or developer's equivalent form, be submitted to GSFC.

#### 10.1.4.1 Materials Used in "Off-the-Shelf-Hardware”

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or changed shall be treated as non-compliant. The developer shall define on a MUA what measures will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include any one, or a combination, of the following: hermetic sealing, vacuum bake-out, material changes for known non-compliant materials, etc. When a vacuum bake-out is the selected method, it shall incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bake-out as well as compliance with the satellite contamination plan and error budget.

### 10.1.5 Conventional Applications (Definition)

Conventional applications or usage of materials is the use of compliant materials in a manner for which there is extensive satisfactory aerospace heritage.

### 10.1.6 Non-conventional Applications (Definition)

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage shall be considered a non-conventional application. In that case, the material usage will be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods.

### 10.1.7 Polymeric Materials

Material acceptability shall be determined on the basis of flammability, toxicity, vacuum outgassing and all other materials properties relative to the application requirements and usage environment.

### 10.1.8 Shelf-Life-Controlled Materials

Polymeric materials that have a limited shelf life shall be controlled by a process that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf life, and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings

#### 10.1.9.1 Fasteners

The developer shall comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in GSFC S-313-100, Goddard Space Flight Center Fastener Integrity Requirements. Material test reports for fastener lots shall be submitted for information.

Fasteners made of plain carbon or low alloy steel shall be protected from corrosion. When plating is specified, it shall be compatible with the space environment. On steels harder than RC 33, plating shall be applied by a process that is not embrittling to the steel.

### 10.1.10 Lubrication

The developer shall prepare and document a lubrication usage list as part of the MIL. In addition, the developer may be requested to submit supporting applications data.

Lubricants shall be selected for use with materials on the basis of valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination effects.

All lubricated mechanisms shall be qualified by life testing in accord with the life test plan or heritage of an identical mechanism used in identical applications.

## 10.2 PROCESS SELECTION REQUIREMENTS

The developer shall prepare and document a material process utilization list as part of the MIL. A copy of any process shall be submitted for review upon request. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings), shall be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

## 10.3 PROCUREMENT REQUIREMENTS

### 10.3.1 Purchased Raw Materials

Raw materials purchased by the developer shall be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance.

### 10.3.2 Raw Materials Used in Purchased Products

The developer shall require that the supplier meet the requirements of 10.3.1 and provide on request the results of acceptance tests and analyses performed on raw materials.

| **MATERIAL USAGE AGREEMENT (MUA)** | | USAGE AGREEMENT NO.: | PAGE OF |
|---|---|---|---|
| PROJECT: | SUBSYSTEM: | ORIGINATOR: | ORGANIZATION : |

| DETAIL DRAWING | NOMENCLATURE | USING ASSEMBLY | NOMENCLATURE |
|---|---|---|---|
| | | | |

| MATERIAL & SPECIFICATION | MANUFACTURER & TRADE NAME |
|---|---|
| | |

| USAGE | THICKNESS | WEIGHT | EXPOSED AREA | ENVIRONMENT | | |
|---|---|---|---|---|---|---|
| | | | | PRESSURE | TEMPERATURE | MEDIA |
| | | | | | | |

| APPLICATION: |
|---|
| RATIONALE: |

| ORIGINATOR: | PROJECT MANAGER: | DATE: |
|---|---|---|
| | | |

**FIGURE 10-1 Material Usage Agreement**

**FIGURE 10-2: STRESS CORROSION EVALUATION FORM**

1. Part Number ________________________________________
2. Part Name __________________________________________
3. Next Assembly Number _______________________________
4. Manufacturer _______________________________________
5. Material ___________________________________________
6. Heat Treatment _____________________________________
7. Size and Form ______________________________________
8. Sustained Tensile Stresses-Magnitude and Direction
    a. Process Residual ____________________________________
    b. Assembly ___________________________________________
    c. Design, Static _______________________________________
9. Special Processing __________________________________
10. Weldments
    a. Alloy Form, Temper of Parent Metal ______________________
    b. Filler Alloy, if none, indicate ____________________________
    c. Welding Process _____________________________________
    d. Weld Bead Removed - Yes ( ), No ( ) ______________________
    e. Post-Weld Thermal Treatment __________________________
    f. Post-Weld Stress Relief ______________________________
11. Environment _______________________________________
12. Protective Finish ___________________________________
13. Function of Part ____________________________________
14. Effect of Failure ____________________________________
15. Evaluation of Stress Corrosion Susceptibility _______________
16. Remarks: __________________________________________

POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT ____________________ SYSTEM/EXPERIMENT ____________________ GSFC T/O ____________________

DEVELOPER/DEVELOPER ____________________ ADDRESS ____________________

PREPARED BY ____________________ PHONE ____________________ DATE PREPARED ____________________

GSFC MATERIALS EVALUATOR ____________________ PHONE ____________________ DATE RECEIVED ____________________ DATE EVALUATED ____________________

| Area, $cm^2$ | Vol., cc | Wt., gm |
|---|---|---|
| 1 0-1 | A 0-1 | a 0-1 |
| 2 2-100 | B 2-50 | b 2-50 |
| 3 101-1000 | C 51-500 | c 51-500 |
| 4 >1000 | D >500 | d >500 |

| ITEM NO. | MATERIAL IDENTIFICATION(2) | MIX FORMULA(3) | CURE(4) | AMOUNT CODE | EXPECTED ENVIRONMENT(5) | REASON FOR SELECTION(6) | OUTGASSING VALUES | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | TML | CVCM |
| | | | | | | | | |

**NOTES**

1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on polymeric and composite materials usage list.
2. Give the name of the material, identifying number and manufacturer. Example: Epoxy, Epon 828, E. V. Roberts and Associates
3. Provide proportions and name of resin, hardener (catalyst), filler, etc. Example: 828/V140/Silflake 135 as 5/5/38 by weight
4. Provide cure cycle details. Example: 8 hrs. at room temperature + 2 hrs. at 150C
5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group. Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen
6. Provide any special reason why the materials was selected. If for a particular property, please give the property.
   Example: Cost, availability, room temperature curing or low thermal expansion.

**FIGURE 10-3 POLYMERIC MATERIALS AND COMPOSITES USAGE LIST**

INORGANIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT ________________ SYSTEM/EXPERIMENT ________________ GSFC T/O ________________

DEVELOPER/DEVELOPER________________ ADDRESS ________________

PREPARED BY________________ PHONE ________________ DATE PREPARED ________________

GSFC MATERIALS EVALUATOR________________ PHONE ________________ DATE RECEIVED ________________ DATE EVALUATED ________________

| ITEM NO. | MATERIAL IDENTIFICATION[2] | CONDITION[3] | APPLICATION[4] OR OTHER SPEC. NO. | EXPECTED ENVIRONMENT[5] | S.C.C. TABLE NO. | MUA NO. | NDE METHOD |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

NOTES:

1. List all inorganic materials (metals, ceramics, glasses, liquids, and metal/ceramic composites) except bearing and lubrication materials that should be listed on Form 18-59C.

2. Give materials name, identifying number manufacturer.
   Example: a. Aluminum 6061-T6
   b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc.
   c. Fused silica, Corning 7940, Corning Class Works

3. Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
   Example: a. Heat treated to Rockwell C 60 hardness, gold electroplated, brazed.
   B. Surface coated with vapor deposited aluminum and magnesium fluoride
   c. Cold worked to full hare condition, TIG welded and electroless nickel plated.

4. Give details of where on the spacecraft the material will be used (component) and its function.
   Example: Electronics box structure in attitude control system, not hermetically sealed.

5. Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
   Example: T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxygen

**FIGURE 10-4 INORGANIC MATERIALS AND COMPOSITES USAGE LIST**

LUBRICATION USAGE LIST

SPACECRAFT________________________ SYSTEM/EXPERIMENT________________________ GSFC T/O____________

DEVELOPED/DEVELOPER________________________ ADDRESS ________________________

PREPARED BY________________________ PHONE________________________ DATE PREPARED ____________

GSFC MATERIALS EVALUATOR ________________________ PHONE____________ DATE RECEIVED ____________ DATE EVALUATED ____________

| ITEM NO. | COMPONENT TYPE, SIZE MATERIAL[1] | COMPONENT MANUFACTURER & MFR. IDENTIFICATION | PROPOSED LUBRICATION SYSTEM & AMT. OF LUBRICANT | TYPE & NO. OF WEAR CYCLES[2] | SPEED, TEMP., ATM. OF OPERATION[3] | TYPE OF LOADS & AMT. | OTHER DETAILS[5] |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

**NOTES**

(1) BB = ball bearing, SB = sleeve bearing, G = gear, SS = sliding surfaces, SEC = sliding electrical contacts. Give generic identification of materials used for the component, e.g., 440C steel, PTFE.

(2) CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation, (<30°), LO = large oscillation (>30°), CS = continuous sliding, IS = intermittent sliding. No. of wear cycles: A(1 -$10^2$), B($10^2$-$10^4$), C($10^4$-$10^6$), D(>$10^6$)

(3) Speed: RPM = revs./min., OPM = oscillations/min., VS = variable speed CPM = cm/min. (sliding applications). Temp. of operation, max. & min., °C Atmosphere: vacuum, air, gas, sealed or unsealed & pressure

(4) Type of loads: A = axial, R = radial, T = tangential (gear load). Give amount of load.

(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness. If SB, give dia. of bore and width. If torque available is limited, give approx. value.

**FIGURE 10-5 LUBRICATION USAGE LIST**

MATERIALS PROCESS UTILIZATION LIST

SPACECRAFT ______________________ SYSTEM/EXPERIMENT ______________________ GSFC T/O ______________

DEVELOPER/DEVELOPER ______________________ ADDRESS ______________________

PREPARED BY ______________________ PHONE ______________________ DATE PREPARED ______________

GSFC MATERIALS EVALUATOR______________________ PHONE ______________ DATE RECEIVED ______________ DATE EVALUATED ______________

| ITEM NO. | PROCESS TYPE(1) | DEVELOPER SPEC. NO.(2) | MIL., ASTM., FED. OR OTHER SPEC. NO. | DESCRIPTION OF MAT'L PROCESSED(3) | SPACECRAFT/EXP. APPLICATION(4) |
|---|---|---|---|---|---|
| | | | | | |

**NOTES**

(1) Give generic name of process, e.g., anodizing (sulfuric acid).

(2) If process if proprietary, please state so.

(3) Identify the type and condition of the material subjected to the process. E.g., 6061-T6

(4) Identify the component or structure of which the materials are being processed. e.g., Antenna dish

**FIGURE 10-6 MATERIALS PROCESS UTILIZATION LIST**

# Chapter 11. Contamination Control Requirements

## 11.0 GENERAL REQUIREMENTS

The developer shall plan and implement a contamination control program for LWS hardware. The developer shall establish the specific cleanliness requirements and delineate the approaches to meet the requirements in a Contamination Control Plan (CCP) deliverable to the LWS Project for concurrence.

Contamination includes all materials of molecular and particulate nature whose presence degrades hardware performance. The source of the contaminant materials may be the hardware itself, the test facilities, and the environments to which the hardware is exposed.

## 11.1 CONTAMINATION CONTROL PLAN

The developer shall prepare a Contamination Control Plan (CCP) that describes the procedures that will be followed to control contamination. The CCP shall establish the implementation and describe the methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime. In general, all mission hardware should be compatible with the most contamination-sensitive components. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging shall be described in detail for each subsystem or component at each phase of assembly, integration, test, and launch.

### 11.1.1 Contamination Control Verification Process

The developer shall develop a contamination control verification process as part of the CCP. The verification process shall be performed in order to allow the:

a. Determination of contamination sensitivity;

b. Determination of a contamination allowance;

c. Determination of a contamination budget;

d. Development and implementation of a contamination control plan.

## 11.2 MATERIAL OUTGASSING

All materials shall be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data shall be established based on each component's operating conditions. Established material outgassing data shall be verified and shall be provided to the LWS Project for review.

## 11.3 THERMAL VACUUM BAKEOUT

The developer shall perform thermal vacuum bakeouts of all hardware as required to protect contamination-sensitive components. The parameters of such bakeouts (e.g., temperature, duration, outgassing requirements, and pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance. Thermal vacuum bakeout results shall be verified and shall be provided to the LWS Project for review.

# Chapter 12. GIDEP Alerts and Problem Advisories

## 12.0 GENERAL REQUIREMENTS

The NPP spacecraft contractor shall participate in the Government/Industry Data Exchange Program (GIDEP). The contractor shall transmit additional copies of documentation sent to GIDEP relevant to the LWS hardware to the NASA/GSFC Systems Assurance Manager (SAM) and to the:

Alert Coordinator

Code 562

NASA Goddard Space Flight Center

Greenbelt, MD 20771.

## 12.1 GIDEP ALERT RESPONSE

The developer shall review and disposition all Government Industry Data Exchange Program (GIDEP) Alerts for impact on flight equipment. New parts procurements and parts pulled from storage shall be continuously checked for impact. Parts pulled from inventory for flight shall hav e the alert history checked for the period dating back to the date code marked on the parts. In addition, the deverloper shall review and disposition any NASA Alerts and Advisories provided to the developer by the LWS Project. Alert applicability, impact, and corrective actions shall be documented and status provided to the LWS Project on a monthly basis.

In the event of a conflict between GIDEP alerts and NASA Advisories, the NASA Advisory shall govern.

## 12.2 DOCUMENTATION

The developer shall keep parts and materials selection and usage records sufficient to determine applicability of any Government Industry Data Exchange Program (GIDEP) alerts related to materials used for LWS.

# Chapter 13. Applicable Documents List

| DOCUMENT | DOCUMENT TITLE |
|---|---|
| ANSI/ASQ Q9001-2000 | Model for Quality Assurance in Design, Development, Production, Installation, and Servicing |
| ANSI/IPC-A-600 | Acceptance Criteria for Printed Wiring Boards |
| ANSI/J STD 001 | Requirements for Soldered Electrical and Electronic Assemblies (not allowed for space flight hardware) |
| ASTM E-595 | Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment |
| EWR 127-1 | Eastern and Western Range Safety Requirements |
| GEVS-SE | General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components, rev A, dated June 1996 |
| GSFC 311-INST-001 | Instructions for EEE Parts Selection, Screening, and Qualification |
| GSFC PPL-21 | Goddard Space Flight Center Preferred Parts List |
| GSFC S-312-P003 | Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses |
| GSFC S-313-100 | Goddard Space Flight Center Fastener Integrity Requirements |
| IPC-2221 | Generic Standard on Printed Board Design |

| | |
|---|---|
| IPC-6011 | Generic Performance Specification for Printed Boards |
| IPC-6012 | Qualification and Performance Specification for Rigid Printed Boards<br><br>Flight Applications – Supplemented with: GSFC/S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses |
| IPC-6013 | Qualification and Performance Specification for Flexible Printed Boards |
| ISO 17025 | General Requirements for the Competence of Testing and Calibration Laboratories |
| KHB 1710.2D | Kennedy Space Center Safety Practices Handbook |
| MIL-STD 1629A | Procedures for Performing a Failure Mode Effects and Criticality Analysis |
| MSFC-HDBK-527 | Material Selection List for Space Hardware Systems |
| MSFC-SPEC-522 | Design Criteria for Controlling Stress Corrosion Cracking |
| NASA Reference Publication (RP) 1124 | Outgassing Data for Selecting Spacecraft Materials |
| NASA RP-1161 | Evaluation of Multi-layer Printed Wiring Boards by Metallographic Techniques |
| NASA-STD-6001 | Flammability, Odor, Off-gassing and Compatibility Requirements & Test Procedures for Materials in Environments That Support Combustion |

| | |
|---|---|
| | (Replaces NAS 5300.4(3M)) |
| NASA-STD-8739.3 | Requirements for Soldered Electrical Connections Replaces NHB 5300.4(3A-2) |
| NASA-STD-8739.4 | Requirements for Crimping Inter-connecting Cables, Harnesses, and Wiring (Replaces NHB5300.4(3G)) |
| NASA-STD-8739.5 | Fiber Optics Termination Standard |
| NASA-STD-8739.7 | Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) |
| NASA-STD-8719.13A | NASA Software Safety Standard |
| NSS 1740.14 | Guidelines and Assessment Procedures for Limiting Orbital Debris |
| S-311-M-70 | Specification for Destructive Physical Analysis |

# Chapter 14. Acronyms and Definitions

## 14.0 ACRONYMS

| | |
|---|---|
| ABPL | As-Built Parts List |
| ABML | As-Built Materials List |
| ANSI | American National Standards Institute |
| ASIC | Application Specific Integrated Circuits |
| ASQ | American Society for Quality |
| BB | Ball Bearing |
| BOL | Beginning of Life |
| CCB | Configuration Control Board |
| CCP | Contamination Control Plan |
| CDR | Critical Design Review |
| CIL | Critical Items List |
| CM | Configuration Management |
| CONR | Confirmation Review |
| COTR | Contracting Officer's Technical Representative |
| CPT | Comprehensive Performance Test |
| CVCM | Collected Volatile Condensable Mass |
| DoD | Department of Defense |
| DPA | Destructive Physical Analysis |
| EEE | Electrical, Electronic, and Electromechanical |
| ELV | Expendable Launch Vehicle |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| FMEA | Failure Modes and Effects Analysis |
| FOR | Flight Operations Review |
| FRB | Failure Review Board |

| | |
|---|---|
| GSFC | Goddard Space Flight Center |
| I&T | Integration and Test |
| ISO | International Standards Organization |
| IV&V | Independent Verification and Validation |
| LRR | Launch Readiness Review |
| LWS | Living With a Star |
| MAR | Mission Assurance Requirements |
| MCM | Multi-Chip Module |
| MIL | Materials Identification List |
| MOR | Mission Operations Review |
| MRB | Material Review Board |
| MSFC | Marshall Space Flight Center |
| MUA | Materials Usage Agreement |
| NAS | NASA Assurance Standard |
| NASA | National Aeronautics and Space Administration |
| NHB | NASA Handbook |
| NRCA | Nonconformance Reporting and Corrective Action |
| NSTS | National Space Transportation System |
| OSSMA | Office of Systems Safety and Mission Assurance |
| PAIP | Performance Assurance Implementation Plan |
| PAPL | Project Approved Parts List |
| PCB | Parts Control Board |
| PCP | Parts Control Plan |
| PDR | Preliminary Design Review |
| PER | Pre-Environmental Review |
| PIL | Parts Identification List |
| PIND | Particle Impact Noise Detection |
| PPL | Preferred Parts List |
| PRA | Probabilistic Risk Assessment |

| | |
|---|---|
| SCM | Software Configuration Management |
| SCR | System Concept Review |
| SOW | Statement of Work |
| SQMS | Software Quality Management System |
| SMA | Safety and Mission Assurance |
| SRO | Systems Review Office |
| SRR | Software Requirements Review |
| STS | Space Transportation System (Shuttle) |
| TML | Total Mass Loss |
| TRR | Test Readiness Review |
| V&V | Verification and Validation |

## 14.1 DEFINITIONS

The following definitions apply within the context of this document:

**Acceptance Test**: The validation process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

**Audit:** A review of the developer's or subdeveloper's documentation or hardware to verify that it complies with project requirements.

**Collected Volatile Condensable Material (CVCM**): The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time.

**Comprehensive Performance Test (CPT)**: The operation of a unit in accordance with a defined operational procedure to verify that performance is compliant with all parameters of the specified requirements. CPTs are performed at major project milestones and serve as a quality control screen to detect deficiencies, establish performance baselines, identify subtle changes, and provide accumulated data for trending analyses.

**Configuration**: The functional and physical characteristics of the payload and all its integral parts, assemblies and systems that are capable of fulfilling the fit, form and functional requirements defined by performance specifications and engineering drawings.

**Configuration Control:** The systematic evaluation, coordination, and formal approval/disapproval of proposed changes and implementation of all approved changes to the design and production of an item the configuration of

**Critical:** A potential failure effect which would result in a significant (as defined by the project) performance degradation of an item of hardware or a mission.

**Derating:** The reduction of the applied load (or rating) of a device to improve reliability or to permit operation at high ambient temperatures.

**Designated Representative:** An individual (such as a NASA plant representative), firm (such as assessment developer), Department of Defense (DOD) plant representative, or other government representative designated and authorized by NASA to perform a specific function for NASA. As related to the developer's effort, this may include evaluation, assessment, design review, participation, and review/approval of certain documents or actions.

**Destructive Physical Analysis (DPA):** An internal destructive examination of a finished part or device to assess design, workmanship, assembly, and any other processing associated with fabrication of the part.

**Design Qualification Tests**: Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either "prototype" or "protoflight" test levels.

**Electromagnetic Compatibility (EMC)**: The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

**Electromagnetic Interference (EMI)**: Electromagnetic energy, which interrupts, obstructs, or otherwise degrades or limits the effective performance of deliverable hardware.

**Electromagnetic Susceptibility**: Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

**End-to-End Tests**: Tests performed on the integrated ground and flight system, including all elements of the payload, its control, stimulation, communications, and data processing to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

**Failure**: A departure from specification that is discovered in the functioning or operation of the hardware or software.

**Failure Modes and Effects Analysis (FMEA):** A procedure by which each credible failure mode of each item from a low indenture level to the highest is analyzed to determine the effects on the system and to classify each potential failure mode in accordance with the severity of its effect.

**Functional Tests:** The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

a. **Part**: A hardware element that is not normally subject to further subdivision or disassembly without destruction of design use. Examples include resistor, integrated circuit, relay, connector, bolt, and gaskets.
b. **Subassembly**: A subdivision of an assembly. Examples are wire harness and loaded printed circuit boards.
c. **Assembly**: A functional subdivision of a component consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole. Examples are a power amplifier and gyroscope.
d. **Component**: A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem's operation. Examples are electronic box, transmitter, gyro package, actuator, motor, battery.
e. **Section**: A structurally integrated set of components and integrating hardware that form a subdivision of a subsystem, module, etc. A section forms a testable level of assembly, such as components/units mounted into a structural mounting tray or panel-like assembly, or components that are stacked.
f. **Subsystem**: A functional subdivision of a payload consisting of two or more components. Examples are structural, attitude control, electrical power, and communication subsystems. Also included as subsystems of the payload are the science instruments or experiments.
g. **Instrument**: A spacecraft subsystem consisting of sensors and associated hardware for making measurements or observations in space.
h. **Module**: A major subdivision of the payload that is viewed as a physical and functional entity for the purposes of analysis, manufacturing, testing, and record keeping. Examples include spacecraft bus, science payload, and upper stage vehicle.
i. **Payload**: An integrated assemblage of modules, subsystems, etc., designed to perform a specified mission in space. For the purposes of this document, "payload" and "spacecraft" are used interchangeably. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.
j. **Spacecraft**: See Payload. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.

**Limited Life Items:** Spaceflight hardware (1) that has an expected failure-free life that is less than the projected mission life, when considering cumulative ground operation, storage and on-orbit operation, (2) limited shelf life material used to fabricate flight hardware.

**Margin:** The amount by which hardware capability exceeds mission requirements

**Nonconformance**: A condition of any hardware, software, material, or service in which one or more characteristics do not meet requirements. As applied in quality assurance, nonconformances fall into two categories—discrepancies and failures. A discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

**Offgassing**: The emanation of volatile matter of any kind from materials into a pressurized volume.

**Outgassing**: The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

**Single Point Failure:** A single element of hardware the failure of which would result in loss of mission objectives, hardware, as defined for the specific application or project for which a single point failure analysis is performed.

**Temperature Cycle**: A transition from some initial temperature condition to temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

**Thermal Balance Test**: A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

**Thermal-Vacuum Test**: A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test, including the gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

**Total Mass Loss (TML):** Total mass of material outgassed from a specimen that is maintained at a specified constant temperature and operating pressure for a specified time.

**Vibroacoustics**: An environment induced by high-intensity acoustic noise associated with various segments of the flight profile; it manifests itself throughout the payload in the form of directly transmitted acoustic excitation and as structure-borne random vibration.

**Workmanship Tests**: Tests performed during the environmental validation program to verify adequate construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Thus random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted parts, etc. Cycling between temperature extremes during thermal-vacuum testing and the presence of electromagnetic interference during EMC testing can also reveal the lack of proper construction and adequate workmanship.